FINAL DRAFT
Kissimmee Basin Modeling, and Operations Study

Alternative Evaluation System Technical Design Document

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1.0 INTRODUCTION

The Kissimmee Basin Modeling and Operations Study (KBMOS) is a comprehensive planning effort being undertaken to improve the water management operations within the Kissimmee Basin. Detailed background information on the basin and this study exists in other documents produced by the study and others and that information is not duplicated here. A summary of key documents describing the background work that has been completed is provided in Appendix A.

Water management in the Kissimmee Basin has been evolving since the 1880s when efforts began to make the Kissimmee River commercially navigable. After decades of navigation as the primary interest, land development and increased population brought flood control and protection interests into focus as the highest priority in the basin. Between 1961 and 1971, a major Federal flood control project was constructed in the basin to address these interests. Unintended negative impacts of the flood control project on the environment spurred several decades of study and other actions focused on restoring the lost environmental values of the basin. In 1990s, a second Federal project was initiated to restore a large portion of the Lower Kissimmee Basin (LKB) and to revitalize portions of the Kissimmee Upper Basin (KUB). Work on this Federal project is more than half complete at this time. While the restoration efforts have progressed, new concerns have emerged in the basin for the future of water supply, the management of nuisance levels of aquatic plants in the KUB, and the impacts of basin discharges into downstream ecosystems (Lake Okeechobee).

This history of concerns and the actions to address them have provided a basis for articulating the objectives of this study. Additionally, the results of extensive stakeholder interaction have supplemented the framing of the study's objectives. Present water management operations of the Federal flood control project reflect the earlier priorities of navigation and flood control and to limited degrees, water conservation for recreation, water supply, fisheries, and aquatic plant management. The Kissimmee River Restoration Project necessitates revision of Kissimmee River Basin operating criteria, subject to certain constraints (such as preserving existing flood control), to ensure that the benefits expected from the Federally-mandated restoration efforts can be achieved.

The goal of KBMOS is to assess whether existing operating rules, schedules, and criteria for the water control structures in the Kissimmee Basin can be modified to achieve a more acceptable balance among flood control, water supply, aquatic plant management, and natural resource water management objectives. Given the other objectives for water management in the basin and related constraints, this is a very challenging task. While water management in this basin since the flood control project has technically been multi-objective, it has been in reality largely single-objective. That is, the flood control objective has been primary and the other objectives were accommodated to the degree convenient to the flood control objective. This study will attempt to maximize the benefits to the natural resource objectives without negatively affecting the current level of flood control, while providing water supply for urban uses, allowing for aquatic plant management practices and attempting to address the needs of downstream ecosystem within the existing infrastructure and land holdings of the State of Florida.

The existing operating rules, schedules, and criteria were typically challenging to develop, but not nearly as difficult as the challenges faced in this study. Many aspects of operating for the benefit of the environment can be diametrically opposed to flood control. Fortunately, this restoration project is well conceived in that it includes extensive land purchases to allow re-flooding of floodplains and includes provisions for additional seasonal storage of runoff in Lakes Kissimmee, Hatchineha, and Cypress that will be used to meet environmental restoration needs while not violating existing flood control levels of service. Additionally, the other objectives and constraints mentioned above add degrees of difficulty to this study.

Well founded planning studies devise and implement methods for addressing complexities such as those described above. In this study, a number of "best practices" from other sophisticated water resources planning studies have been employed to insure that this study can meet these challenges. These include the development of potential operating rules, schedules, and criteria, or "alternative plans" of high quality and likelihood of improving present conditions. The manner in which each alternative plan, if implemented, would produce desirable outcomes will be "simulated" or mimicked by the use of advanced computer models that are industry standards and/or state of the art tools. Finally, these simulated outcomes will be evaluated in systematic ways that allow comparisons and contrasts between and among the alternative plans to support the ultimate selection of the best alternative plan for meeting the study's objectives within the study's constraints.

Development of this systematic evaluation process or "Alternative Evaluation System" (AES) is the focus of this document. The concepts and components that comprise the AES will be discussed as well as how the components will be integrated into a system and how that system will be applied. The proposed Alternative Evaluation System is based on the concepts from multi-attribute utility theory and analytic hierarchy process from the field of decision science. The study team has identified key characteristics that must be incorporated for the AES to be successful:

- Unbiased
- Transparent
- Repeatable
- Documentable
- Implementable

This document is a guide for the actual development and implementation of the AES which will be undertaken in subsequent activities of the KBMOS, prior to the initiation of the Alternative Plan Selection Process. It is currently planned to implement the recommendations within this document concurrent with the Base Condition Implementation Phase that will start early in CY2007. The development and implementation will provide ample opportunities for stakeholder input into the process, weights, and other specifics of the AES.

2.0 OVERVIEW OF THE KBMOS PLANNING PROCESS

In the proposed KBMOS planning process, a number of "best practices" from other water resources planning studies have been employed to insure that this study can meet these challenges. These include developing "alternative plans" which are potential operating rules, schedules, and criteria that score well across all performance measures. The likely performance of each alternative plan, as it would be implemented, will be simulated by computer models (See Appendix A for a summary of KBMOS key documents). These simulated performances will be evaluated in systematic ways that allow comparisons and contrasts between and among the alternative plans. This will support the ultimate selection of the preferred alternative plan for meeting the study's objectives within the study's constraints.

2.1 PLANNING

Planning in water resources is essentially a structured way to formulate and evaluate alternative plans within a study process in order to select and justify a future course of action. A number of key terms have been defined specifically for use in this study. Some of them useful in discussing the AES are provided here.

Operating Objectives

- Overarching, guiding principles for operating the lakes and water control structures
- Organize project responsibilities in groups that allow each group to be addressed and indications of how and to what degree each will be met
    - Flood Control
    - Water Supply
    - Aquatic Plant Management
    - Natural Resources requirements of the Kissimmee River Restoration and Kissimmee Chain of Lakes
    - Downstream Ecosystems (Lake Okeechobee)

Operating Criteria

- Specify detailed "rules" for operating each lake and water control structure
- Address when and how spillway gates are opened and closed
- Based on specifics like a maximum or minimum water level or rate of flow
- Incorporates physical safety of structures and physical limitations of structure operations

Alternative Plans

- Define (in this study) a set of proposed operating criteria
- Formulated to increase benefits and/or better balance the benefits that result from water management in the basin for and/or across one or more of the operating objectives

Performance Measures

- Metrics devised to measure the increase or decrease in benefits that could be expected to result from changes in water management in the basin if a given alternative plan is implemented
- Provide a way to compare differences in the likely performance between alternative plans within operating objective.
    - Flood Control
    - Water Supply
    - Aquatic Plant Management
    - Natural Resources requirements of the Kissimmee River Restoration and Kissimmee Chain of Lakes
    - Downstream Ecosystems (Lake Okeechobee)

Base Conditions

- Provide a means to make valid comparisons between alternative plans
- Specify and “fix,” “freeze,” or hold static certain variables and factors that affect hydrology that are independent of the alternative plans
    - Land Use/Land Cover/Water Use
    - Physical Configuration Project Features
- Several Base Conditions are strategically defined
    - “Existing Conditions”
        - 2000 Land Use and corresponding water use
        - Phase I River Restoration complete
    - “Future Conditions”
        - 2025 Land Use and corresponding water use
        - River Restoration complete
        - Implementation of Headwaters Revitalization

At its highest level, the KBMOS planning process weaves together a number of very technical steps that are used to move from alternative plan formulation using stakeholder and other input to the final selection of the best plan. This process is depicted in Figure 2.1-1. In this figure, the flow of process and work is generally from left to right. This process begins with the basic planning tasks shown in the upper left box. As a result of completing these basic planning tasks, simulation models have been chosen and are being implemented. Extensive work has been undertaken to develop performance measures for use in this study and are documented in the Draft Final Evaluation Performance Measures report (PBS&J, 2006). In this figure, for simplicity, alternative plan formulation and evaluation are contained in a single box across the top. The primary message of this figure is depicted by the yellow arrows—as work progresses from left to right, there is extensive interaction between the development of performance measures, alternative plan formulation, evaluation, and modeling. The actual interactions are too complex to show in one figure. If well executed, the result of employing this process will result in the selection of the preferred alternative plan as depicted by the star at the right side of the figure.

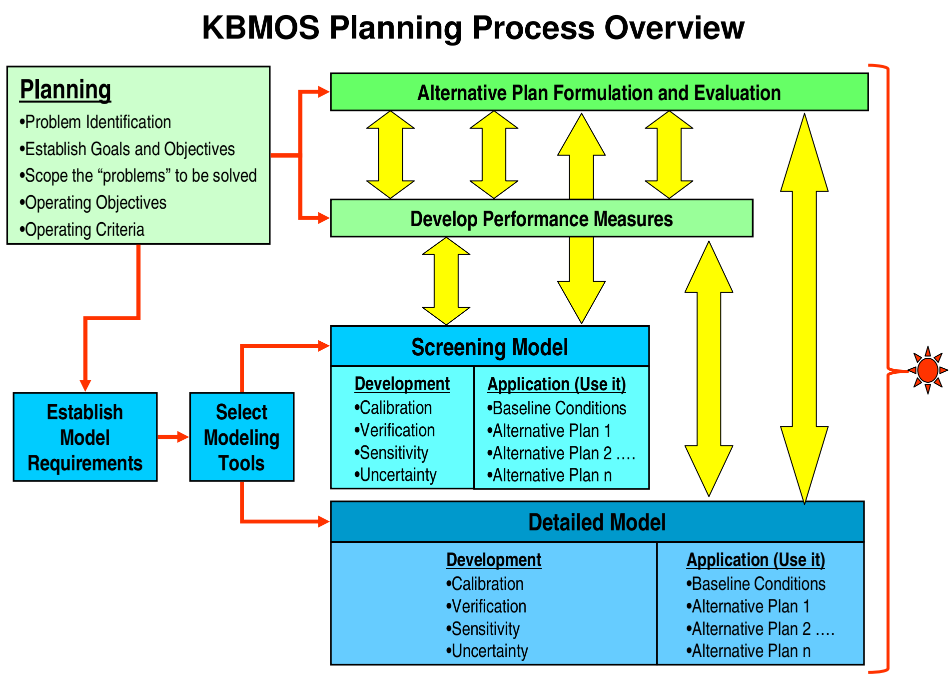

Figure 2.1-1 Overview of the KBMOS Planning Process

The discussion developed here will be further explained in subsequent sections and is discussed in greater detail in other efforts such as:

- Phase 1 Basin Assessment, Section 1.7 Model Plan/Strategy (Earth Tech 2005a)
- Task 1.9 Kissimmee Basin Model Development Work Plan (Earth Tech. 2005b)
- Base Condition Summary Report (Earth Tech 2006)

2.2 PLAN FORMULATION

Alternative Plans will be developed based on input from stakeholders and other basin information. This effort will primarily involve defining specific plan components such as the way a particular lake or water control structure might be operated under a specific condition or specific time of year. A number of these components can be aggregated to form a composite set of components. Components and composite sets of components can be combined in strategic ways to comprise a set of potential operating rules, schedules, and criteria for the entire basin, thus *formulating* an alternative plan. This is depicted in Figure 2.2-1. As can be seen in the figure, some alternative plans can share common components while having some components unique to each.

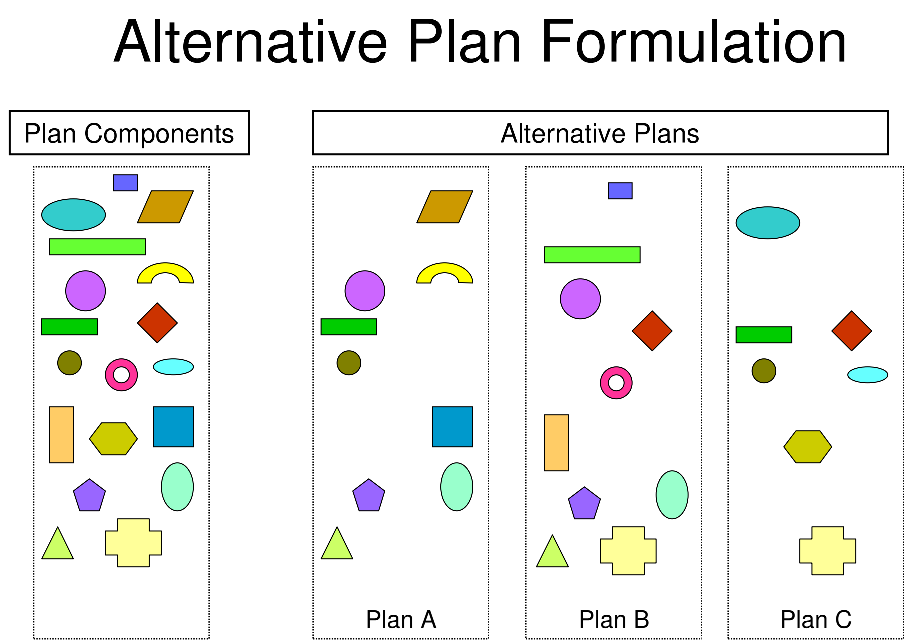

Figure 2.2-1 Alternative Plan Formulation

Plan formulation is an essential step in putting the ideas and concepts that are considered ways to improve operations into a format with sufficient specificity that the computer models can simulate how the alternative plan can be expected to perform if it is implemented.

As the planning process proceeds and a large number of alternative plans are evaluated and reduced to few of the best performing alternative plans, the best ideas and concepts from mediocre and poor performing alternative can be "recycled" into other existing alternative plans or used to make new ones during the modeling and evaluation process. This recycling of the best ideas and concepts as the planning process moves forward is known as *reformulation*. Reformulation will be used in this study to the extent it can likely improve the outcome of the study.

2.3 PERFORMANCE MEASURES

An extensive effort recently completed has produced a set of draft final performance measures (PMs) for use in the KBMOS. These are well documented in the Draft Final Evaluation Performance Measure report (PBS&J, 2006). These performance measures will be used in the AES as the basic units of measurement for assessing how well each alternative plan meets the study's objectives or operates within the study's constraints.

Performance measures provide the bridge between scientific and other knowledge and understandings of the basin and the computer models as shown in Figure 2.3-1.

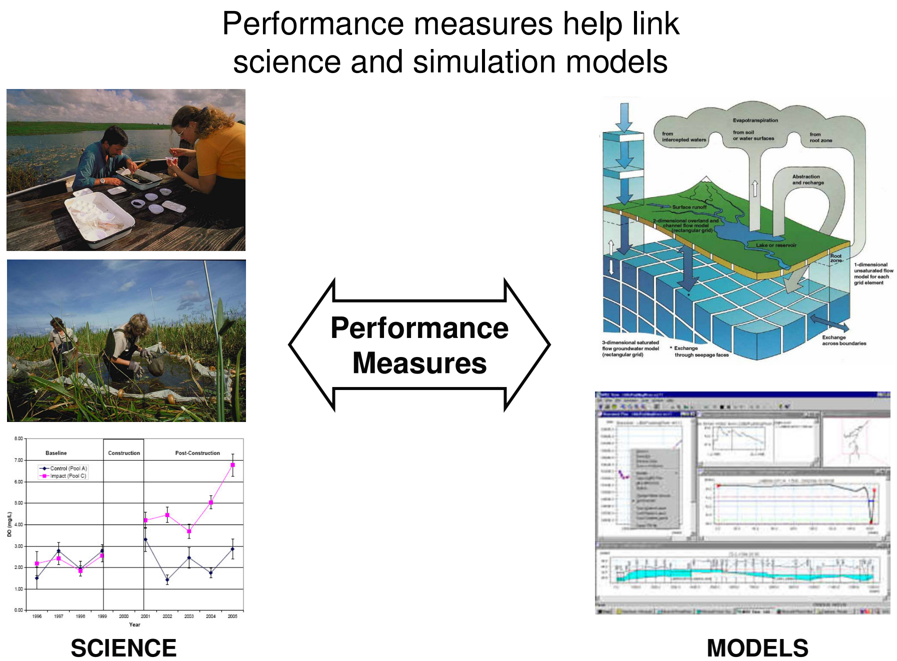

Figure 2.3-1 Performance Measures Link Science and Computer Models in Planning Studies

PMs link science to other disciplines through establishing relationships and metrics are meaningful to others including:

- Water control operators
- Engineers (modelers/designers/constructors)
- Economists
- Managers and policy makers
- Stakeholders

PMs integrate and translate scientific (or other) knowledge and understanding into logical and conditional metrics, usually specifying a target, target range, failure range(s), utility index function that represents the relative "goodness" of a condition or outcome, and/or other measures for determining how well or how poorly a particular action (stressor) will create an ecological (or other) effect and produce a desired outcome (attribute).

Section 4 explains how PMs will be incorporated into the AES and be used in the KBMOS.

2.4 SIMULATION MODELS

As the KBMOS planning process progresses through the three levels (rounds or cycles) of modeling and evaluation—screening level, formulating level, and evaluation level—alternative plans are simulated with modeling tools with increasing sophistication and resolution. As the plans are promoted and refined, the models employed at each subsequent level are more sophisticated in terms of spatial and temporal resolution as well as its physical domain. Model selection criteria, models selected, and how they are applied are documented in other KBMOS reports (Appendix A). Section 2.6 explains in more detail how these three levels of modeling will be incorporated into the AES.

2.5 ALTERNATIVE PLAN EVALUATION

As part of the systematic approach built into the AES, each alternative plan will be evaluated in the same way. The only exception to this is as alternative plans are promoted from one level of the planning analysis to the next and the models provide a higher resolution of output, performance measures that were not supported by model output in earlier levels of analysis will be added to the evaluation. When this occurs, all evaluations within a given level will receive the same treatment. As the planning process progresses through the three levels (Screening, Formulation, and Evaluation) the total number of alternative plans reviewed and number promoted to the next level will change as many plans will exist at the start of the process and only a few will progress to the end of the process.

To demonstrate how alternative plans well be evaluated, the screening level step is depicted in Figure 2.5-1 through Figure 2.5-5 shown below. During the screening level, it is estimated that 50 to 100 alternative plans will be formulated and simulated. When the AES is applied to these results, it is expected that an estimated 10 to 20 alternative plans will be "promoted" to the next level (formulation) of the alternative plan selection process.

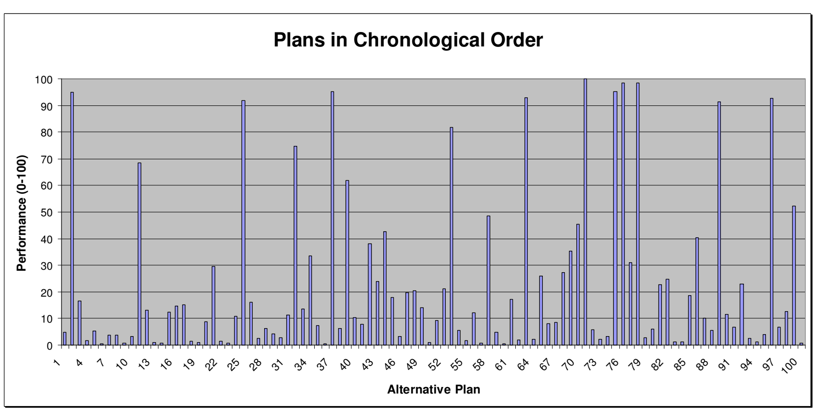

Figure 2.5-1 Example of 100 alternative plans plotted by their performance measured on a scale of 0-100 and displayed in the order indicated by each plan's ordinal number.

After completing the simulations for all the alternative plans, their relative performances can be depicted as in Figure 2.5-1. Next, the alternative plans can be sorted based on ranking them from highest performance to lowest performance as in Figure 2.5-2.

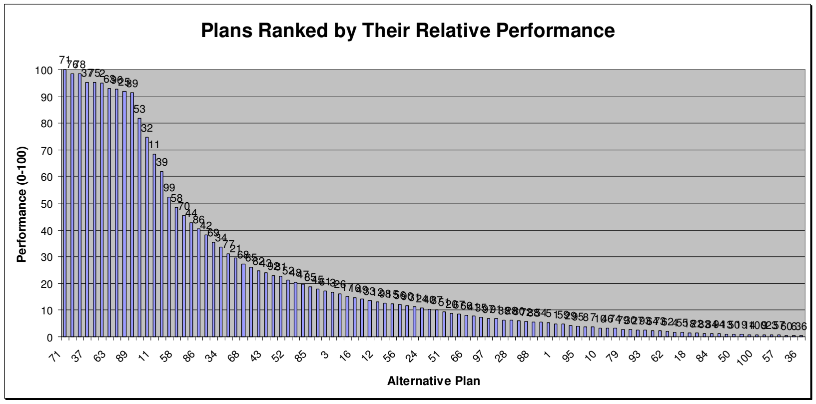

Figure 2.5-2 Example of 100 alternative plans sorted and plotted by ranking from highest to lowest performance.

Since the screening round will select the best performing 10-20 alternative plans for promotion to the next level of evaluation, it is convenient to focus on the 25 top-ranked plans. This is depicted in Figure 2.5-3.

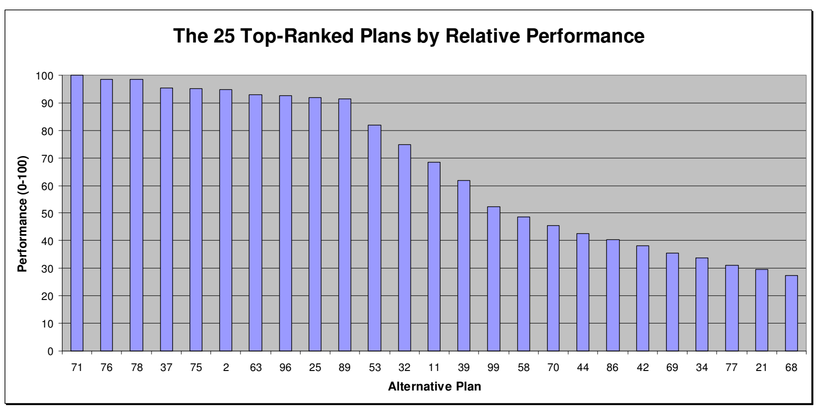

Figure 2.5-3 Example of displaying the 25 top-ranked alternative plans for use in determining the 10-20 plans that will be promoted to the next level.

The 10 top-ranked plans will be promoted to the next level by the commitment to promote 10-20 plans. The promotion threshold will be established in the zone between the 10th and 20th ranked plans as shown in Figure 2.5-4.

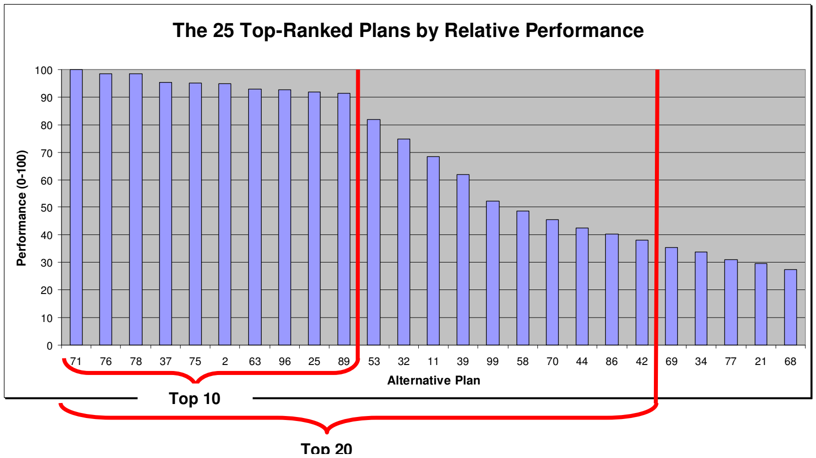

Figure 2.5-4 Example of selecting the zone where the promotion threshold will be established, in this case between the 10th and 20th highest performing alternative plans.

Finally, a threshold for promoting alternative plans to the next level of evaluation can be established within agreed criteria from analyzing relative performance once simulation results are available. In this example, as shown in Figure 2.5-5, a threshold is established between the 12th and 13th top-ranked plans. In this way, the 12 top-ranked plans will be promoted to the next level of evaluation.

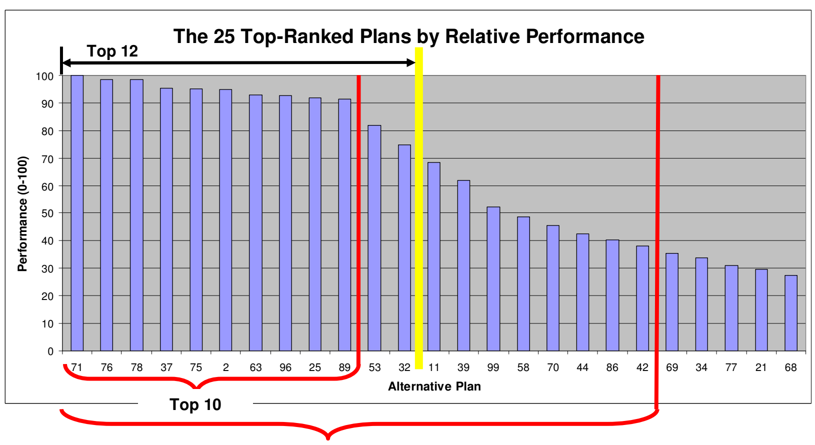

Figure 2.5-5 Example of setting the promotion threshold between the 12th and 13th top-ranked plans which will promote the 12 top-ranked plans to the next level of evaluation.

Following the completion of the formulation level analysis, it is expected that the top 3 to 5 alternative plans will be promoted to the evaluation level. The methodology applied during the evaluation level efforts will be the same as the previous levels throughout the alternative selection process. The Alternative Evaluation System methodology will be used to rank the top three plans in the order of their performance for presentation to decision makers for final selection of the preferred plan

The setting of the promotion threshold is a critically important step. Ideally, this should be done with a view to being inclusive towards promotion rather than exclusive. When evident, a significant break in performance between two alternative plans is typically a good place to establish the threshold. Many careful assessments of simulation results and detailed performance results can be used to establish the threshold. If any stakeholder(s) believes the threshold wrongly eliminates a favored alternative plan that falls slightly below the threshold, it is reasonable to consider and possibly adjust the threshold to include that plan in those that are promoted. This may promote a few plans between the original threshold and adjusted threshold that add to the workload in the next level of evaluation, but may be worth it to make the process as inclusive as possible.

2.6 ITERATIVE EVALUATION

As stated above, the KBMOS planning process incorporates three levels (rounds or cycles) of analysis. Each level will evaluate alternative plans by use of simulation models and the AES. This is presented in several views in three figures that follow.

Within each level, the model will simulate each alternative plan's likely performance by producing output that will be post-processed into forms required by the PMs. For each alternative plan, scores will be determined for each PM. These individual PM scores will be weighted according to a weighting system and combined into a composite score for each alternative plan. These composite scores will be used in establishing the relative ranking of the alternative plans. This concept is depicted in Figure 2.6-1.

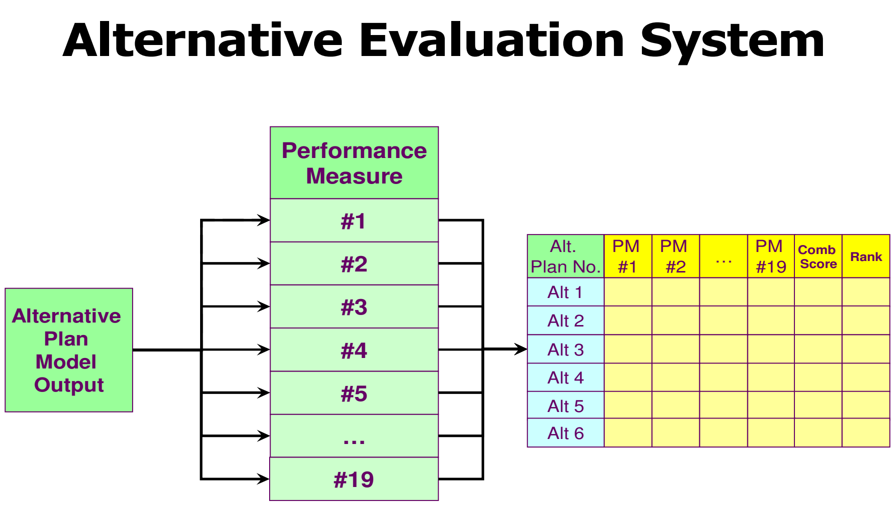

Figure 2.6-1 Model output and performance measures are used to develop scores and a weighted combined or composite score for each alternative plan. These composite scores are used to establish the relative ranking of the alternative plans. This process is used in each level of evaluation.

As the composite scores are developed in one level of evaluation and plans are promoted to the next level of evaluation, the same AES process is applied to the output from each progressively more detailed modeling analysis see Figure 2.6-2.

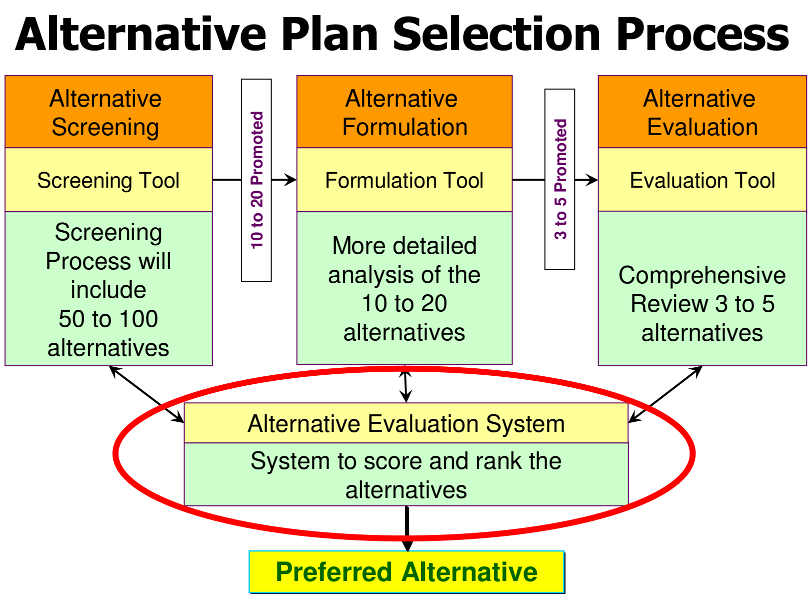

Figure 2.6-2 The same AES process is applied in each level of evaluation with different models and a different number of alternative plans being evaluated and promoted to the next level.

As the scores from each level of evaluation are processed, the top-ranked plans are promoted to the next level. Additionally, the plans not promoted are not completely eliminated. They are kept in a virtual recycle bin for potential use in the reformulation process whereby great performing components of otherwise mediocre or low performing plans can be recycled to make good performing plans better or to develop somewhat new or "hybrid" plans for consideration in the present or next level of evaluation. This is diagramed in Figure 2.6-3.

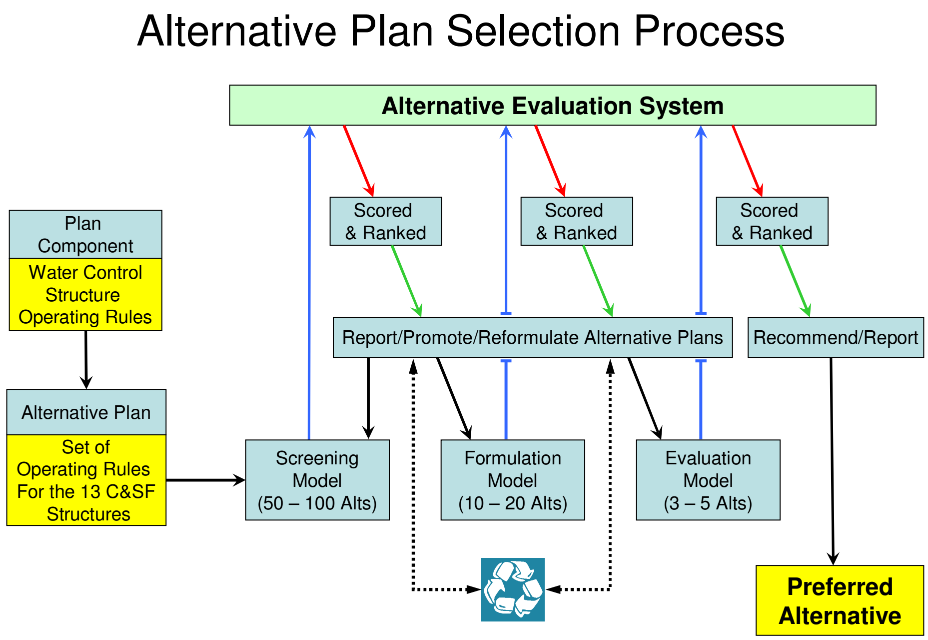

Figure 2.6-3 Diagram of the multi-level evaluation process showing the virtual recycle bin and the alternative plan reformulation process.

This iterative evaluation process is implemented to insure that all plans, components, concepts, and ideas are carefully considered and that none are eliminated from consideration prematurely. In this way, there is greater assurance that the best alternative plan will be recommended as the "preferred alternative."

2.7 REPORTING

Throughout the multi-level evaluation process, the AES will produce numerous summary reports and other output that will be used to translate model output into forms that can be used by the study team and stakeholders to evaluate the relative performance of each alternative. Additionally, these report products will document the entire AES process and the ultimate selection of the preferred alternative plan.

3.0 DECISION SCIENCE

The Alternative Evaluation System is based on advancements developed in the field of decision science. Decision science focuses on how decisions are made and how decision making processes can be improved to produce better decisions. "Better decisions" are decisions that stand the test of time and deliver outcomes that are appropriate and fitting to the decision being made. It has been recommended that KBMOS employ a sophisticated form of decision science utilizing the approaches found in multi-attribute utility theory and analytic hierarchy process. This recommendation is based on the KBMOS work performed to-date and from other similarly complex water management efforts. Section 4 describes the recommended approach to decision science and the development of the scoring and ranking scheme along with the related references.

Most people make hundreds if not thousands of decisions each day. Many of these decisions are straightforward and not very complex. That is they employ very simple decision processes and the quality of the decision is not particularly critical. Examples of this may include what beverage to choose with one's meal. This decision would typically be made quickly with only oneself making the decision. Furthermore, it may be limited to a few choices and if the decision turns out to be a poor one (the beverage tastes bad), no great harm is done as the decision can be reversed (switch to another beverage) and/or another opportunity to make a better choice will occur soon (at the next meal).

Other decisions such as which career to pursue, which job to take, or building a house (what kind/plan, where, when, etc.) are much more complicated. Yet they typically involve only one or a few people. However, the importance of choosing wisely becomes paramount because the decision(s) may not be easily reversible or may not present another opportunity.

In the fields of public works and civil works, such as water resources management, the long-term effects of good and bad decisions underscore the importance of choosing wisely. Public resource decisions such as these are typically much more complex and complicated by the multi-objective nature of the problems and the multi-stakeholder points of view and interests that must be considered. Furthermore, budgetary limitations and other constraints often add to the difficulty of executing good decision making.

Gains in the field of decision science can be applied to support good decision making. For purposes of the KBMOS, several cornerstones of good public resource decision making have been incorporated in the AES and are summarized here. Factors for selecting the appropriate decision process including characteristics of the decisions confronted include:

- Level of complexity of the physical systems involved
- Degree of understanding causes and effects
- Degree of uncertainty causes and effects
- Amount of information available
- Number of and diversity of stakeholders

- Number of and competition between objectives
- Number of and complexity of constraints
- Number of and diversity of options (alternative plans)
- Opportunity to reverse or modify decision in the future
- Impact of a bad decision
- Appropriateness of the process (can it be understood by those applying it and utilizing its results)

Goals listed below are appropriate for every decision making process. Ideally, every decision process should be:

- Unbiased
- Transparent
- Repeatable
- Documentable
- Implementable

Decision processes range from simple to complex as shown below. Simpler processes are the most appropriate in some cases as are the more complex ones in other cases. It is important to employ the least complex process that will result in good decision making.

- Consensus
- Voting
- Expert Opinions
- Simple Scoring Schemes
- Sophisticated scoring and ranking scheme

If the lessons from decision science are appropriately applied, the decision process will help clarify what can be agreed upon and what needs additional solution seeking. Additionally, applying an appropriate decision process often brings stakeholders of differing views to better and more productive understandings of each other and can be helpful in resolving entrenched special interest opinions. “Appropriate” is a critical word here as attempting to make difficult decisions with a decision process that is too simple or too complex for the problem can do more harm than good.

4.0 THE KBMOS ALTERNATIVE EVALUATION SYSTEM

As discussed in the previous section, the Alternative Evaluation System for the KBMOS is an application of concepts from multi-attribute utility theory and analytic hierarchy process from the field of decision science. To be successful, the AES must meet the following goals:

- Unbiased
- Transparent
- Repeatable
- Documentable
- Implementable

Additionally, the AES must meet these two very important requirements:

- Make distinctions between plans
- Provide a basis for relative ranking of plans

The AES consists of four major components or features which will be explained in further detail in this section.

- Performance Measures (what will be measured)
- High-Quality Metrics (individually and collectively, how measurements will be made for each performance measure and for the set of performance measures, see also Section 4.2)
- Process for applying Performance Measures and Metrics (how all the parts fit together and are used)
- Reporting Results (consistent, understandable, outputs that can be readily evaluated and compared by the end users—agencies and stakeholders)

In this section, three new concepts will be introduced and explained to illuminate how the AES works.

- Utility Index Functions
- Objective Weights
- Performance Measure (Attribute) Weights

4.1 PERFORMANCE MEASURES

As stated earlier, extensive work has been devoted to the development of performance measures for the KBMOS. Documentation of the performance measures is provided in Draft Final Evaluation Performance Measures report (PBS&J 2006) and only limited information is repeated here.

Table 4.1-1 is a reproduction of Table 3 from the Draft Final Evaluation Performance Measures report that lists the 19 performance measures slated for use in the KBMOS. To the extent possible, given resolution and other computer model limitations within each level of evaluation, each performance measure will be evaluated for each base condition and each alternative plan.

No.	Name	Operating Objectives				
		FC	WS	AP	NR	LO
1	Kissimmee River Continuous Flow				X	
2	Seasonality and Variability of Kissimmee River Flow				X	
3	Kissimmee River Stage Hydrograph / Floodplain Hydroperiod				X	
4	Kissimmee River Stage Recession / Ascension				X	
5	Kissimmee River Channel Velocity				X	
6	Kissimmee River Energy Grade Line				X	
7	Kissimmee River Probable Flood Extents	X				
8	Flow Duration				X	
9	Stage Duration for Navigation		X			
10	Probable High Lake Stages	X				
11	Seasonality and Variability of Lake Stages				X	
12	Frequency and Duration of High and Low Lake Stages				X	
13	Lake Stage Recession				X	
14	Lake Littoral Zone Inundation				X	
15	Sub-watershed Runoff Volume	X				
16	Water Supply for Consumptive Use		X			
17	Lake Discharges and Stages for Hydrilla Management			X		
18	Kissimmee River Flows to Lake Okeechobee					X
19	Isolated Wetland Hydroperiod				X	

FC = Flood Control WS = Water Supply AP = Aquatic Plant Management LO = Downstream Ecosystems (Lake Okeechobee)
NR = Natural Resources Requirements of the Kissimmee River Restoration Project and/or the Kissimmee Chain of Lakes

Table 4.1-1 Table of performance measures developed for use in KBMOS (reproduced from the Draft Final Evaluation Performance Measures report).

For the purposes of this document, examples developed below will refer to the fourth PM: "E-04 Kissimmee River Stage Recession / Ascension" which was developed to evaluate how well operations are able to meet the targets for stage recession and ascension along the restored sections of the Kissimmee River.

Each PM will have one or more evaluation components which are the specific characteristics that will be assessed from the model output. Additionally, each PM will have one or more evaluation locations which are the specific location(s) where each evaluation component will be assessed. For example, if a PM has three evaluation components and two evaluation locations, there will be six (6) assessments made for the PM for each alternative plan. The evaluation components and locations will be combined to create a composite performance score for each Evaluation Performance Measure within an alternative plan. Composite performance scores will be developed in a manor similar to the aggregate alternative plan scores through the use of utility functions and weighting factors to combine evaluation component scores for the evaqluation locations.

When the final specifications for the KBMOS Evaluation Performance Measures are developed, instructions detailing how these evaluation component/evaluation location permutations will be combined into a composite performance score for each PM will be included.

Additionally, each evaluation component has a specified target or target range that is location specific. The degree to which the simulation of an alternative plan predicts that the alternative plan will meet, exceed, or fall short of the target is expressed in terms of the value of that outcome. In some instances, nearly meeting a target may be almost as valuable as meeting or exceeding it. In other instances, there may be no value in nearly meeting a target just as completely missing the target. These value assessments for simulated outcomes are expressed in utility index functions for each evaluation component (and evaluation location as appropriate). Utility index functions are explained in Section 4.2.

4.2 UTILITY INDEX FUNCTIONS

The types of outcomes assessed by the PM evaluation components are the metrics that have been defined for this AES. These metrics are designed to be high quality in that they are well suited to capture and report the range of outcomes possible for each evaluation component. In most of the evaluation components, these metrics are continuous, complex functions instead of simple, discrete points within a range.

The values of different positions along each continuous metric are represented in a utility index function. These functions are constructed based on knowledge and understanding of the PM and the desirability of a given outcome (its value in meeting the stated objectives of the study) relative to other potential outcomes for a given evaluation component. These values are expressed on a scale of 0 to 1 with 0 assigned to outcomes that have no value and 1 assigned to outcomes that have the greatest value. Other outcomes are distributed between 0 and 1 in a manner that reflects their relative values. Figure 4.2-1 depicts an example of a performance measure (E-04) and a corresponding set of possible outcomes, utility index function, and utility values (specific points on the utility index function. In this example, the metric has been simplified by providing four discrete choices as possible model outcomes instead of using the more complex continuous function. The example shows how outcome “c” is almost as valuable as “d” and that “b” is almost as valueless as “a.” These utility values will be used later in a sample calculation. (Note: The line drawn for the utility index function in Figure 4.2-1 does not necessarily represent a relationship between the biology and the hydrology. However, the line is needed as a means to show the differences between outcomes from different model simulations.)

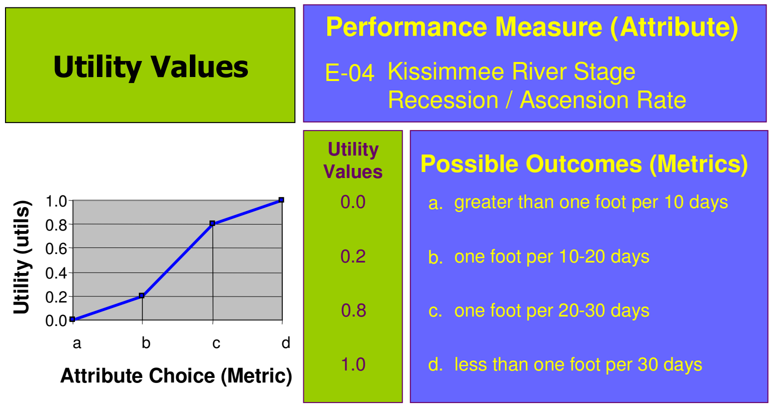

Figure 4.2-1 Example of using a utility index function and determining specific utility values for each of four possible model outcomes for a simplified version of E-04 Kissimmee River Stage Recession / Ascension.

Utility index functions are simply graphical means for expressing what is known and understood about the "goodness" or "desirability" of a particular outcome. This goodness or desirability can be expressed as an absolute measure or a relative measure where each outcome has an associated utility value that fits relatively within other values associated with other outcomes.

There are several special cases of utility index functions that can help explain how they are constructed and/or how they should be conceptualized. For example, if little or no knowledge or understanding is available to allow one outcome to be valued better than another (all outcomes are equally good or equally bad), then the utility index function is a horizontal line that intercepts the vertical axis at 1.0. With this function, all outcomes receive the same utility value, 1.0. This essentially "deactivates" this utility index function and its corresponding evaluation component in the weighting and scoring calculation. Other examples include the "binary" case, where each outcome is simply perfect or unacceptable (black and white, no middle ground) where an outcome will receive either a 1.0 or 0.0 for a utility value. Utility index functions can take the form of a step function, a linear form, or second or higher order relationships.

It is imperative that each utility index function be as well developed as possible but not be "over-developed" where its shapes or nuances suggest more than is known or understood. Utility index functions embody a key part of the grading scheme that links the scientific knowledge and understanding, the less subjective part of alternative plan evaluation, to the AES. Developed wisely, utility index functions become workhorses in automating the evaluation process and significantly aid in meeting the AES goals of providing an unbiased, transparent, repeatable, documentable, and implementable process.

Each performance measures' evaluation components have proposed utility index functions developed and are documented in the Draft Final Evaluation Performance Measures report. Revisions to the utility index functions are anticipated to occur during refinement process.

4.3 DECISION HIERARCHY AND OBJECTIVE WEIGHTS

The AES will develop a decision hierarchy for implementation of a weighted process for study objectives. Decision hierarchies are logical maps of how the objectives of a multi-objective problem are to be organized for decision making. Objectives can be treated as logical equals or they can be nested or grouped in ways that reflect other logical hierarchies. Implementation of the Alternative Evaluation System will include the development of a decision hierarchy for this study. Examples of decision hierarchies are shown in Figure 4.3-1.

As depicted in Figure 4.3-1(c) there are instances where one objective may not be possible or appropriate to evaluate quantitatively and it may be assessed only qualitatively and/or "for information purposes only." These objectives are referred to as performance indicators in the KBMOS. There are study-specific reasons for this which must be carefully considered. Sometimes, it is more useful to treat binary metrics in this way where any outcome will result in a value of 0 or 1 on the utility scale, in other words, it is a "pass/fail" measure. If a pass/fail condition is included in the quantified, weighted combined scoring process, there may be many outcomes where two very different performing alternative plans score essentially the same because they both "fail." It is often more useful and insightful to note the pass/fail outcome (which may be ultimately important) and leave it out of the quantified, weighted combined score so that the assessment of outcomes can be made that allow questions like: "if all other things are equal, which alternative plan performs best for these selected objectives?" Other examples include cases where not enough information is known to properly construct a utility index function. These special cases will be addressed in the final Evaluation Performance Measures.

In conjunction with developing the decision hierarchy, the weighting process is also developed to express relative importance of the study objectives. There are several processes for establishing objective weights. Figure 4.3-2 shows one method for establishing the relative importance of the objectives which can then be used to impute objective weights as shown in Table 4.3-1. Finally, these imputed weights can be distributed on the objectives as shown in Figure 4.3-3.

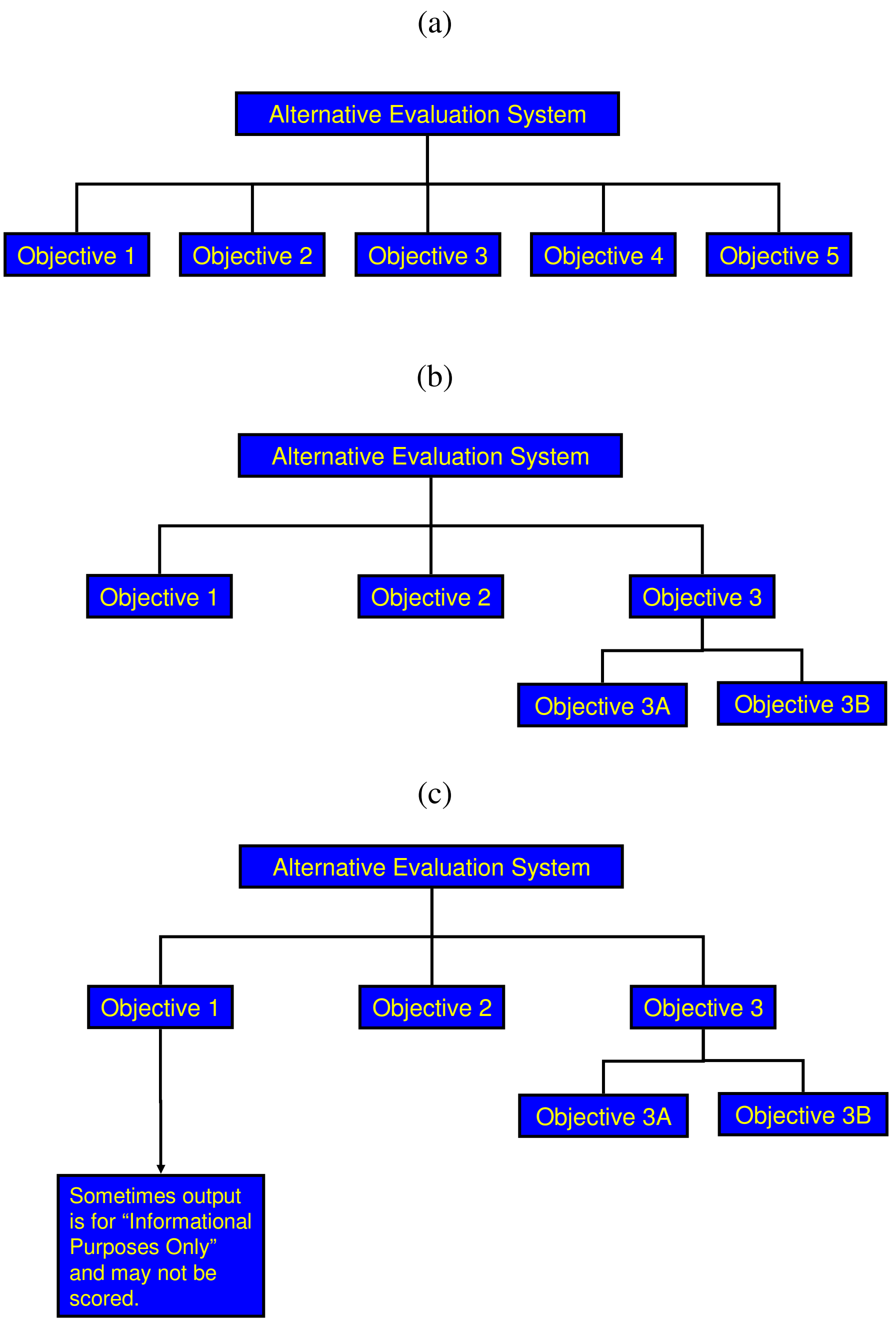

Figure 4.3-1 Examples of decision hierarchies that logically group objectives within an AES. (a) depicts a hierarchy where all objectives are logically equal; (b) depicts a hierarchy where two objectives are nested together under one of three logically equal objectives; and, (c) depicts a similar case as (b) but shows an example where one objective may not be possible or appropriate to evaluate quantitatively and it may be assessed only qualitatively and/or “for information purposes only.”

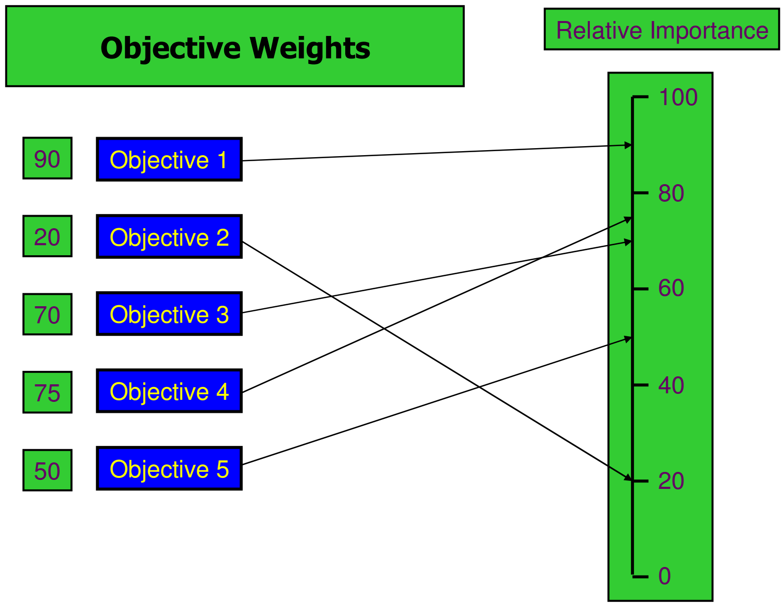

Figure 4.3-2 Example of establishing relative importance of objectives in order to impute objective weights.

	Relative Importance	Imputed Weight	Imputed Weight (Rounded)
Objective 1	90	29.51	29
Objective 2	20	6.56	7
Objective 3	70	22.95	23
Objective 4	75	24.59	25
Objective 5	50	16.39	16
SUM		100.00	100

Table 4.3-1 Example of calculating imputed weights.

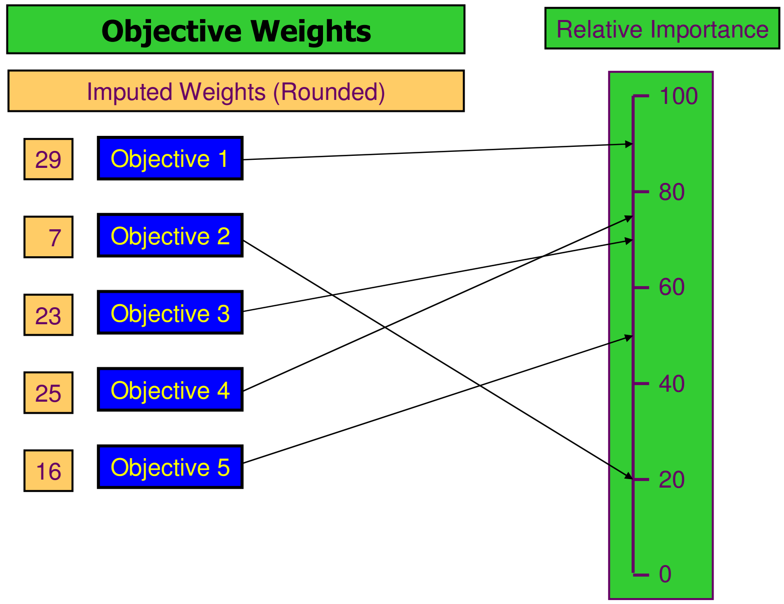

Figure 4.3-3 Example of how imputed weights are distributed to the objectives.

Objective weights are the part of the AES that represent the more subjective, non-scientific component of the alternative plan evaluation process. The missions and policies of the agencies; the social, political, and economic realities that bear on the study; and, the values of the stakeholders are all factors of the objective weights. Appropriately developed, objective weights will reflect a winning compromise or integration of these factors which are often competitive and/or contradictory. A number of steps will be undertaken to assure that all these factors and their respective values or relative importance by agency and stakeholder will be collected, evaluated, and integrated into one set of imputed weights for this study. These steps and the integration of the results will be well documented to support the AES goals of providing an unbiased, transparent, repeatable, documentable, and implementable process. This approach is used widely in the US and other countries in civil works and public works planning processes. The US Army Corps of Engineers has employed this process in some of their water resources planning studies such as the following study:

US Army Corps of Engineers, US Bureau of Reclamation, and the New Mexico Interstate Stream Commission (joint-lead agencies), Draft Environmental Impact Statement–Upper Rio Grande Basin Water Operations Review, Bureau of Reclamation, Albuquerque, New Mexico, 2006.

Objective weights and the decision hierarchy will be established as part of the implementation of the Alternative Evaluation System for the KBMOS. The consultant will gather input for developing the weights and hierarchy from individual staff members of the interagency project team, members of the public, and other stakeholders. Additionally, the consultant will assess agencies' policies to determine which policies are appropriate to be included in developing the weights and hierarchy and how they should be incorporated. Finally, the consultant will synthesized this input into a recommendation for initial final weights and hierarchy and deliver it to the SFWMD for concurrence or further direction to readdress any aspects of it. After simulation model output is available and the AES is initially applied, there may need to be further refinement of the weights and hierarchy. This potential for refinement exists during the screening, formulating, and evaluating steps in the alternative plan evaluation process. Any changes to the weights and hierarchy as a result of refinement will also be submitted to the SFWMD as a recommendation from the consultant for concurrence or further direction as in the initial step for developing weights and hierarchy. The process for developing weights and hierarchy as described here will be documented as it proceeds including any potential changes due to refinements during application.

4.4 DISTRIBUTING OBJECTIVE WEIGHTS

Once the decision hierarchy and the objective weights are established, the performance measures can be organized within the decision hierarchy to follow the logical relationships of performance measures to objectives. An example of this is shown in Figure 4.4-1.

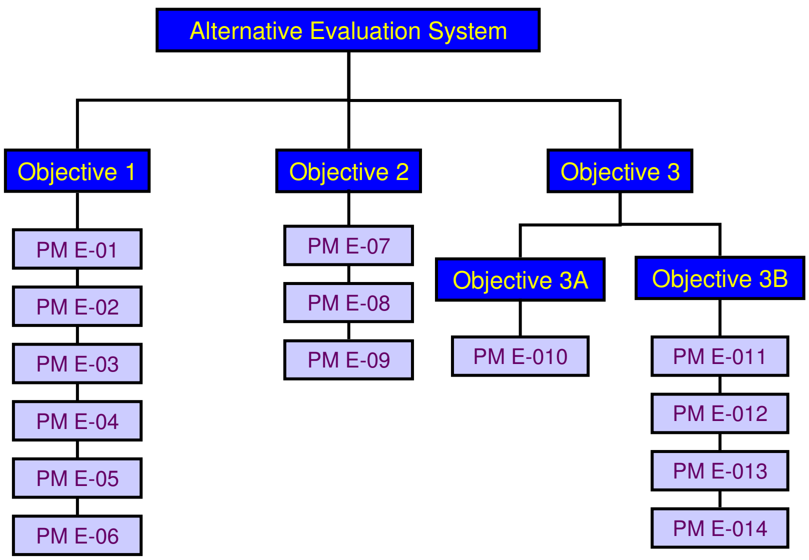

Figure 4.4-1 Example of logically organizing performance measures within a decision hierarchy.

After performance measures are organized within the decision hierarchy, the imputed weights for each objective can be allocated or further distributed to the performance measures. There are several methods for distributing these weights and in the example in Figure 4.4-2, the relative importance method used for objective weights is used again here

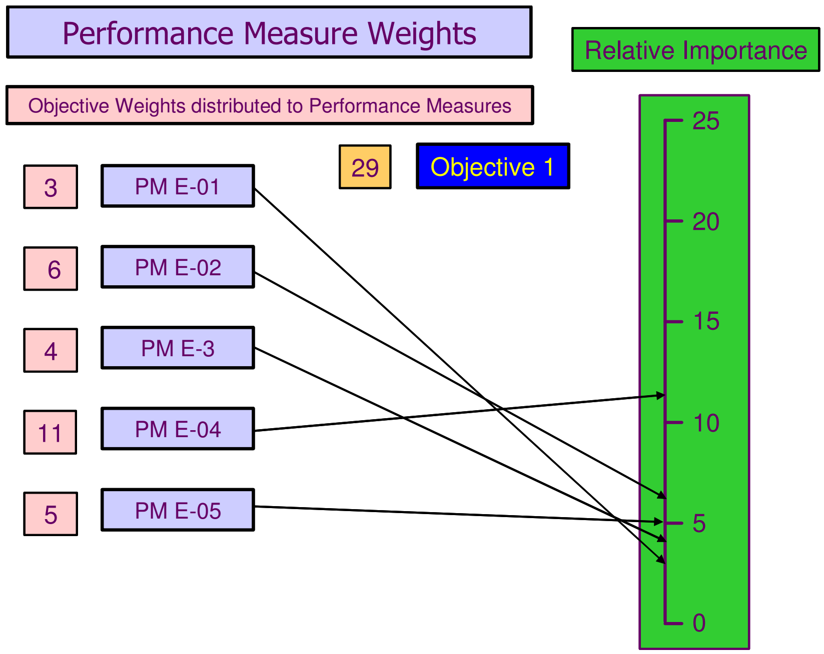

Figure 4.4-2 Example of allocating or distributing objective weights to the performance measures organized under the objective.

Objective weights for each objective are distributed in the same way to the performance measures that are organized under each objective. When this is completed for the entire decision hierarchy, the allocation or distribution of weights is complete as shown in the example in Figure 4.4-3.

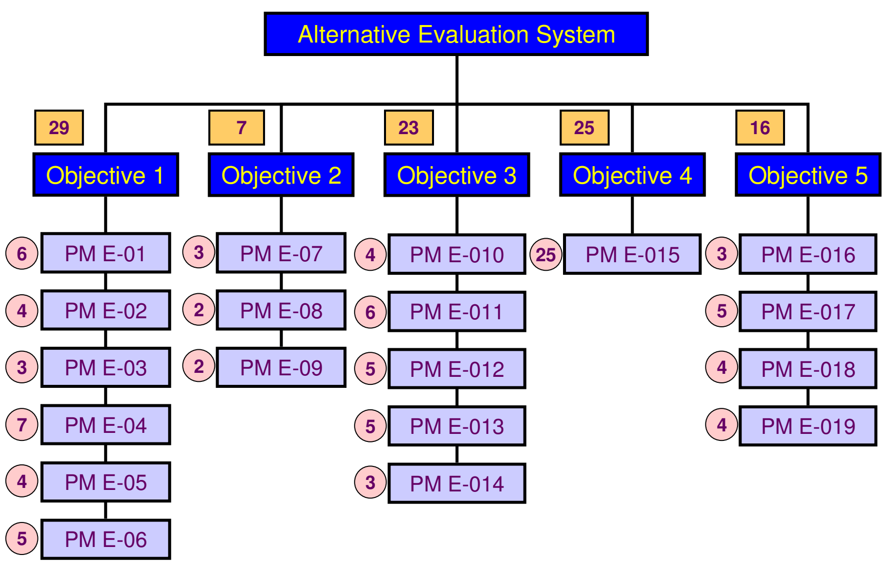

Figure 4.4-3 Example of completing the allocation or distribution of weights for an entire decision hierarchy.

The performance measures will be organized in the decision hierarchy and the objective weights will be distributed from the objectives to the performance measures within each objective as part of the implementation of the Alternative Evaluation System and as specified in the Final Evaluation Performance Measure Document.

4.5 CALUCULATING WEIGHTED PERFORMANCE SCORES

When the performance measures, decision hierarchy, the objective weights, and the distributed weights for the PMs are fully developed, model output post-processed into the PM metric forms can be used to calculate composite performance scores for the alternative plans. At the lowest level in this compositing calculation, the same basic calculation is made numerous times. To explain this basic calculation, Figure 4.5-1 and Figure 4.5-2 show how an example model outcome can indicate a particular position "c" on the PM metric. This corresponds to a utility value of 0.8. This utility value is multiplied by the distributed PM weight of 7 to produce a product of 5.6. For this simple example, this calculation shows how all the pieces of the AES fit together. This will be repeated for all alternative plans and PMs.

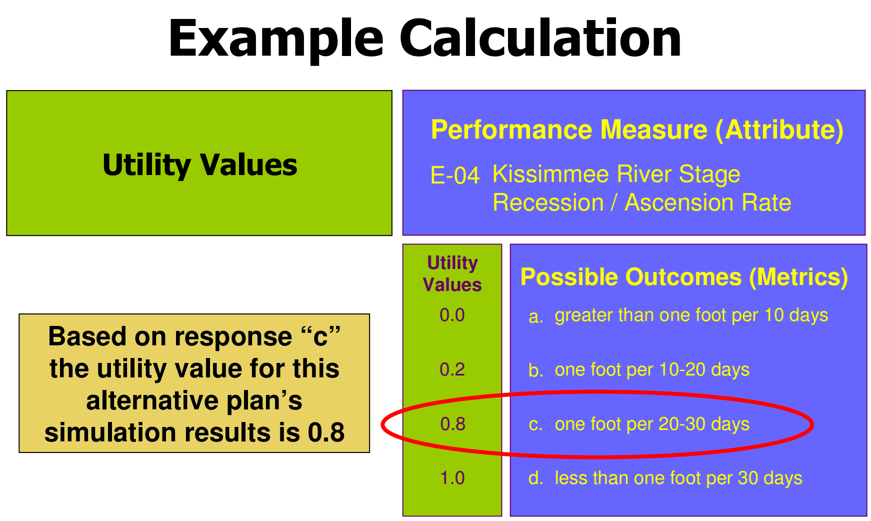

Figure 4.5-1 Example of determining the utility value for one performance measure based on a specific model outcome.

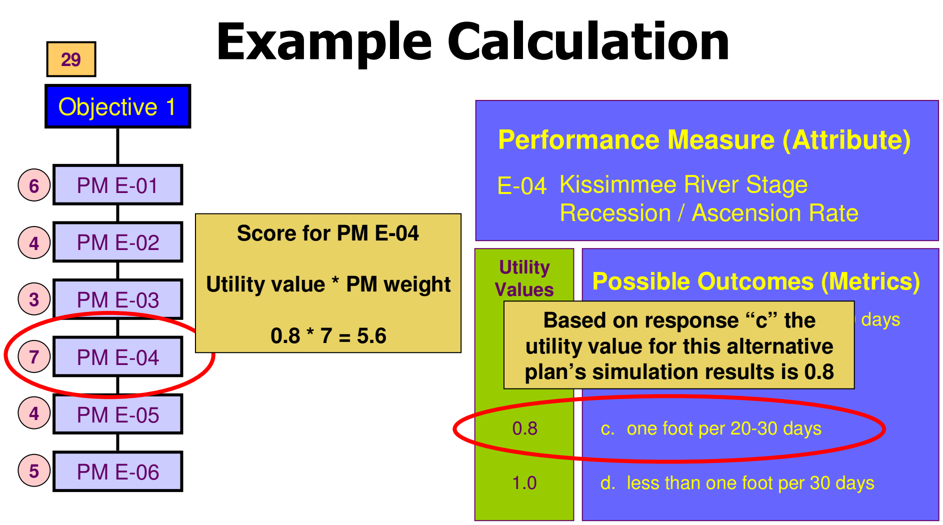

Figure 4.5-2 Example of calculating the weighted performance score for one PM for one alternative plan based the possible outcome predicted by the model output.

An automated process will be established for making these calculations in order to efficiently and accurately process the large number of calculations required by the KBMOS. This process will be developed during a future phase of the study.

4.6 COMPARING RELATIVE PERFORMANCE OF ALTERNATIVE PLAN

As each performance measure's weighted score is calculated for a given alternative plan, a table of the results like the example shown in Table 4.6-1 will be developed and reported with other results from the AES. The composite sum shown in the lower left cell of the table will be used to sort the alternative plans and establish their relative ranking.

Evaluation of Alternative Plan X										
	Performance Measure Choices				Utility Value		Distributed Weight		Weighted Score
	a	b	c	d					
Performance Measure 1				x	0.4	*	6.0	=	2.4
Performance Measure 2		x			0.7	*	4.0	=	2.8
Performance Measure 3			x		0.6	*	3.0	=	1.8
Performance Measure 4			x		0.8	*	7.0	=	5.6
Performance Measure 5	x				0.0	*	4.0	=	0.0
Performance Measure 6		x			0.3	*	5.0	=	1.5
Performance Measure 7				x	1.0	*	3.0	=	3.0
Performance Measure 8			x		0.5	*	2.0	=	1.0
Performance Measure 9				x	0.4	*	2.0	=	0.8
Performance Measure 10		x			0.8	*	4.0	=	3.2
Performance Measure 11		x			0.7	*	6.0	=	4.2
Performance Measure 12			x		0.4	*	5.0	=	2.0
Performance Measure 13		x			0.6	*	5.0	=	3.0
Performance Measure 14	x				1.0	*	3.0	=	3.0
Performance Measure 15		x			0.8	*	2.5	=	2.0
Performance Measure 16				x	0.2	*	3.0	=	0.6
Performance Measure 17			x		0.3	*	5.0	=	1.5
Performance Measure 18		x			0.7	*	4.0	=	2.8
Performance Measure 19				x	0.3	*	4.0	=	1.2
	Composite Performance Score (sum)								42.4

Table 4.6-1 Example of calculation table for one alternative plan for all performance measures.

In addition to the composite performance score calculated as in the example in Table 4.6-1, other modeling and post processing results will be kept for reference and may be reported as necessary for each alternative plan. If qualitative performance indicators are used in the AES as discussed in Section 4.3, they will be included along with the quantitative individual and composite performance scores calculated as shown above.

5.0 SUMMARY

Development and successful application of the AES is essential to the successful completion of the KBMOS. Much work has been completed, especially with the Draft Final Evaluation Performance Measures report (PBS&J, 2006) that is required to fully implement the AES. Subsequent work activities will include tasks to complete the development of the AES according to the needs documented here. During these work activities, input will be collected from stakeholders for finalizing and implementing the AES. The fully developed AES will include significant automation of its calculations and reporting and will have electronic dissemination and review capability to speed the review process.

The AES will provide for sophisticated quantitative scoring and weighting of each alternative plan's performance. While the AES provides several factors for calculating this performance score, it is important to note that certain factors can be deactivated or "turned off" by setting their values to certain default values such that those factors do not have an affect on the calculation. This may be appropriate when testing the sensitivity of the AES or parts of it or when not enough is know to specify values for those factors. This is a key flexibility of the AES planned for this study. It will have the depth and sophistication needed for the most complex PMs that can be quantified and can be simplified when appropriate.

When model output becomes available, especially for the base conditions, a review of the PMs will be conducted in order to provide an opportunity to refine them as necessary to account for any translation problems that occur between the real world and the artificial world of the models.

The PM/AES team will work closely with the Modeling team to carefully integrate the AES with the modeling tools that are being finalized for use in the KBMOS. When the AES is fully completed, it will be thoroughly documented as part of the overall study documentation.

6.0 REFERENCES

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APPENDIX A
Summary of KBMOS Key Documents

Deliverable No.	Key Document Title	Summary of the Key Document Contents
1.8.2 (Phase I)	Kissimmee Basin Hydrologic Assessment, Modeling and Operations Planning - Phase I Basin Assessment	The Phase I Basin Assessment documents the initial work that lead to the Phase II effort. Those tasks include: review of existing data, the identification of operating objectives, and the selection of modeling tools. These work efforts were then used to prepare the model plan for the current planning study.
1.9.3 (Phase I)	Phase II Work Plan	The Phase II work plan provides a description of the Phase II work effort. As a living document, the work plan is updated at key stages of project completion.
2.1.1 (Phase II, Wave 1)	Project Communications Plan	This document provides contact information for key project team members and protocols for accessing, storing, and managing of data and electronic documents via the project ftp and websites. This document also provides guidance to the project team on the generation of written and electronic documents.
2.3.6.2.1 (Phase II, Wave 1)	Screening Tool Proof of Concept Test Plan	Documents the comparison of the O-KCOL and UKISS models. Identifies the criteria used to select the KBMOS Screening Tool.
2.3.6.2.4.1 (Phase II, Wave 1)	Screening Tool Technical Design Document	Defines the conceptual approach and technical goals for development of the Screening Tool. Proposed model construction and calibration data sources are identified.
2.3.6.2.4.2 (Phase II, Wave 1)	O-KCOL Documentation	Summarizes development of the O-KCOL model. Includes a comparison of the O-KCOL model to the UKISS model and documents the validation of the O-KCOL model.
2.3.6.3.6 (Phase II, Wave 1)	Alternative Formulation and Evaluation Tool Technical Design Document	Defines the conceptual approach and the technical goals for construction of the Alternative Formulation/Evaluation Tool (MIKE SHE/MIKE 11 model). Identifies proposed data sources.
2.3.6.4 (Phase II, Wave 2)	Alternative Formulation/Evaluation Tool Acceptance Test Plan	Identifies the calibration and verification time periods for continuous and event simulations and defines the statistical criteria that will be used to assess model calibration.